

Classical Ballistics by James Pate Williams, Jr., BA, BS, MSwE, PhD

<https://jamespatewilliamsjr.com>

Reference: **Exterior ballistics, 1935** by Ernest Edward Herrmann Chapter 3

Classical ballistics ignores atmospheric effects such as resistance due to the air.

$$v_x = v_0 \cos \theta_0$$

$$v_y = v_0 \sin \theta_0 - gt$$

$$x = \int_0^x d\xi = \int_0^t v_0 \cos \theta_0 d\tau = v_0 t \cos \theta_0$$

$$t = \frac{x}{v_0 \cos \theta_0}$$

$$y = \int_0^y d\eta = \int_0^t (v_0 \sin \theta_0 - g\tau) d\tau$$

$$y = v_0 t \sin \theta_0 - \frac{1}{2}gt^2$$

$$\frac{dy}{dx} = \tan \theta$$

$$y = \frac{v_0 x \sin \theta_0}{v_0 \cos \theta_0} - \frac{gx^2}{2(v_0 \cos \theta_0)^2} = x \tan \theta_0 - \frac{gx^2}{2(v_0 \cos \theta_0)^2}$$

After differentiation of the previous equation, we have:

$$\tan \theta = \tan \theta_0 - \frac{gx}{(v_0 \cos \theta_0)^2}$$

$$\begin{aligned} v^2 &= v_x^2 + v_y^2 = v_0^2(\cos \theta_0)^2 + v_0^2(\sin \theta_0)^2 - 2gtv_0 \sin \theta_0 + g^2t^2 \\ &= v_0^2 - 2gx \tan \theta_0 - \frac{g^2x^2}{2(v_0 \cos \theta_0)^2} = v_0^2 - 2g \left(v_0 t \sin \theta_0 - \frac{1}{2}gt^2 \right) \\ &= v_0^2 - 2gy \end{aligned}$$

$$v = \sqrt{v_0^2 - 2gy}$$

Setting y to the right endpoint 0 we obtain:

$$y = v_0 t \sin \theta_0 - \frac{1}{2}gt^2 = 0$$

$$v_0 \sin \theta_0 - \frac{1}{2}gt = 0$$

$$v_0 \sin \theta_0 - \frac{gx}{2v_0 \cos \theta_0} = 0$$

$$\frac{gx}{2v_0 \cos \theta_0} = v_0 \sin \theta_0$$

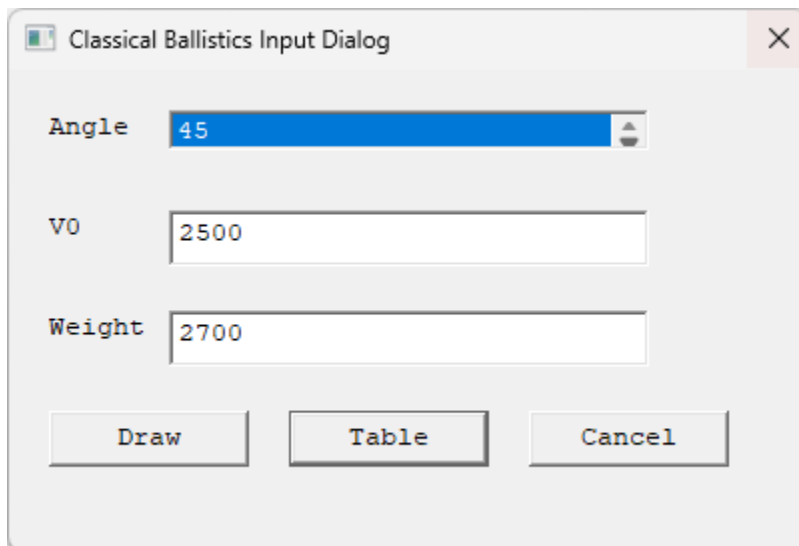
$$x = \frac{2v_0^2 \sin \theta_0 \cos \theta_0}{g}$$

Range X is found to be:

$$X = \frac{v_0^2 \sin 2\theta_0}{g}$$

The time of flight is:

$$T = \frac{X}{v_0 \cos \theta_0}$$



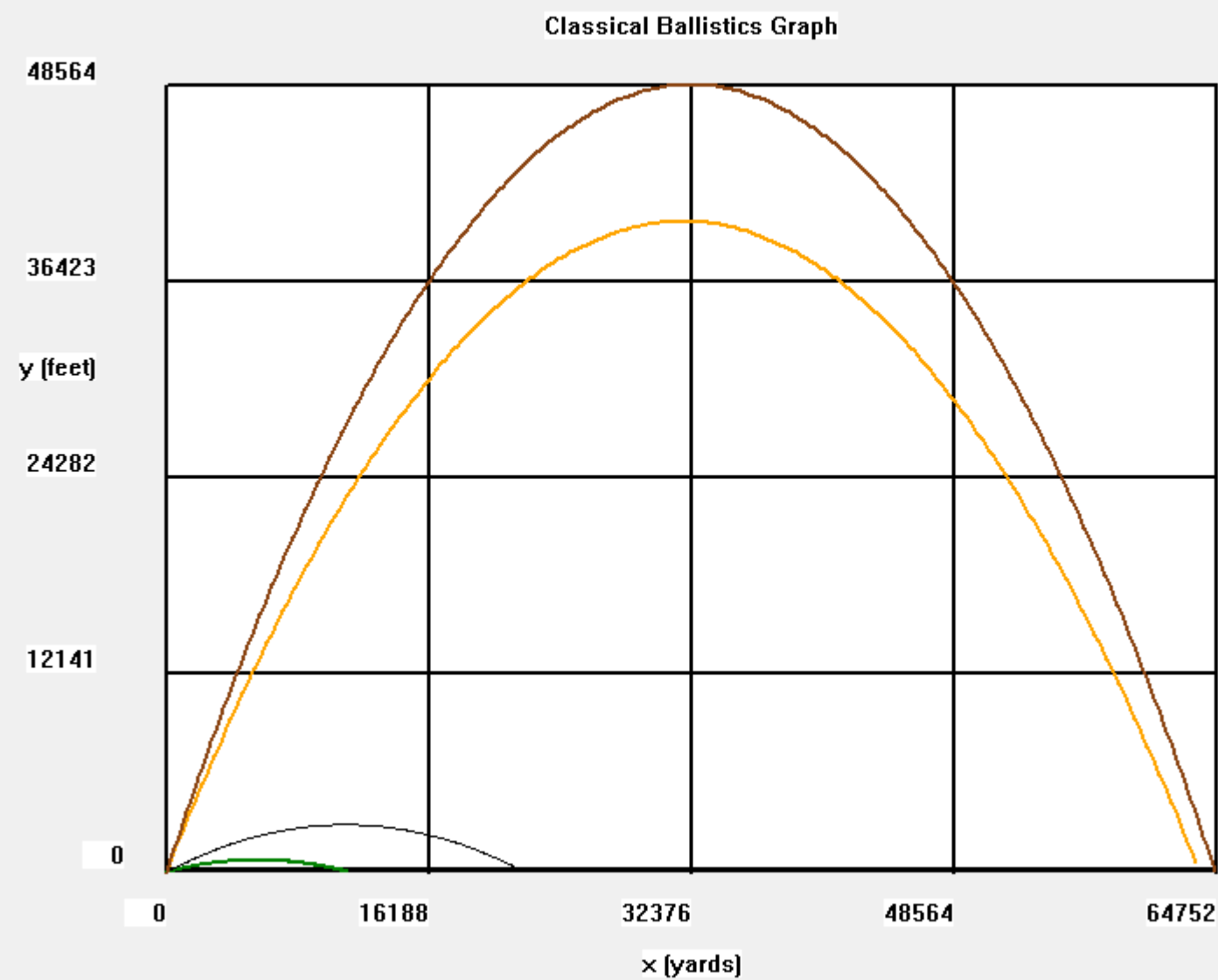
A screenshot of a software window titled "Classical Ballistics Input Dialog". The window has a standard macOS-style title bar with a close button (X) in the top right corner. Inside the window, there are three input fields: "Angle" with a value of 45, "V0" with a value of 2500, and "Weight" with a value of 2700. Below these fields are three buttons: "Draw", "Table", and "Cancel".

Classical Ballistics Table Dialog

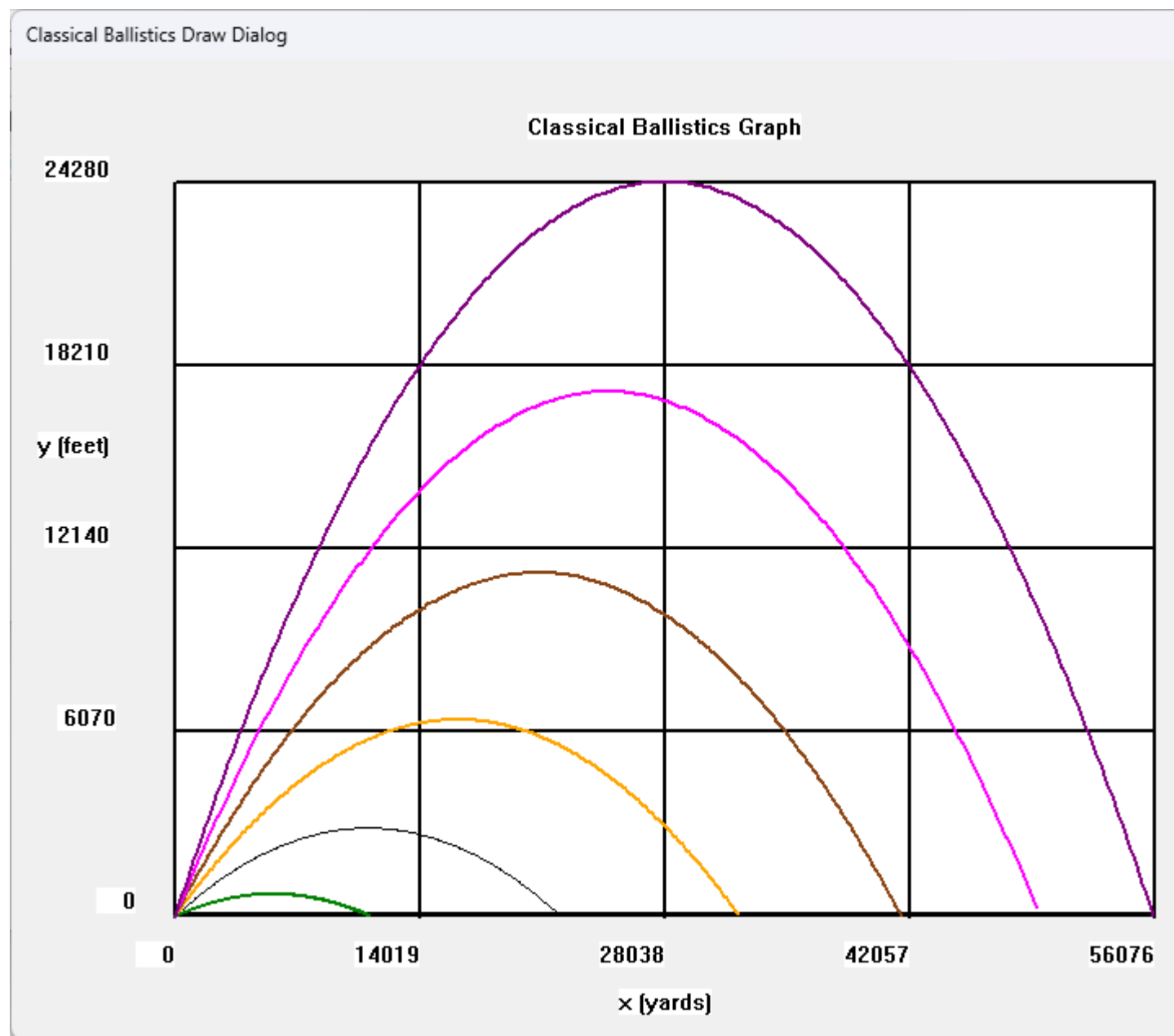
Angle (Degrees)	=	5
V0 (Feet/Sec)	=	2500
Weight (Pounds)	=	2700
Range (Yards)	=	11244
Summit (Feet)	=	738
TOF (Seconds)	=	14
Angle (Degrees)	=	10
V0 (Feet/Sec)	=	2500
Weight (Pounds)	=	2700
Range (Yards)	=	22147
Summit (Feet)	=	2929
TOF (Seconds)	=	27
Angle (Degrees)	=	40
V0 (Feet/Sec)	=	2500
Weight (Pounds)	=	2700
Range (Yards)	=	63768
Summit (Feet)	=	40131
TOF (Seconds)	=	100
Angle (Degrees)	=	45
V0 (Feet/Sec)	=	2500
Weight (Pounds)	=	2700
Range (Yards)	=	64752
Summit (Feet)	=	48564
TOF (Seconds)	=	110

Compute Cancel

Classical Ballistics Draw Dialog



Plots of 5, 10, 40, and 45 degrees



Plots from 5 to 30 degrees inclination in increments of 5 degrees